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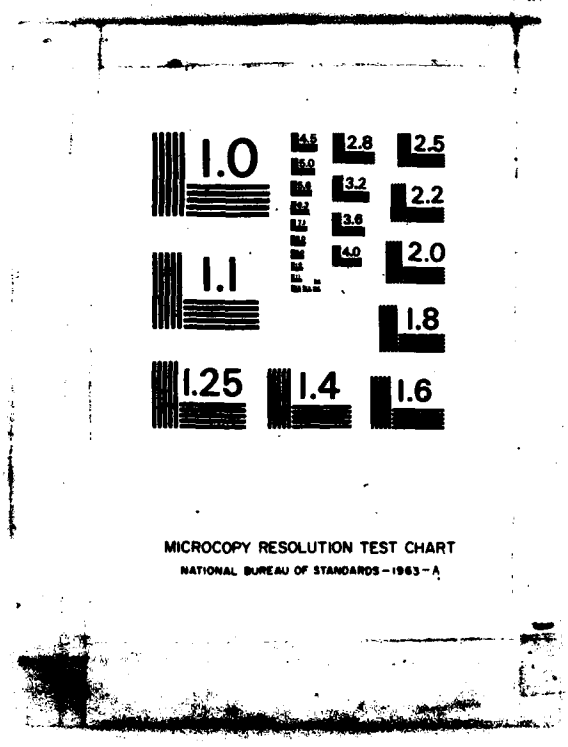
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During the grant year several studies have been undertaken. These are reported fully in References 1, 2, and 3. A summary of the technical highlights follows. An extended nonlinear indicial approach to modeling nonlinear aerodynamic forces for aeroelastic analyses has been developed. The basic approach is based upon describing function ideas.

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FINAL SCIENTIFIC REPORT

Grant - AFOSR-81-0213

WITH PRINCETON UNIVERSITY

AEROELASTIC ANALYSIS USING NONLINEAR AERODYNAMIC METHODS

PRINCIPAL INVESTIGATOR: Earl H. Dowell
TECHNICAL MONITOR: Anthony K. Amos

August 1983

INTRODUCTION

During the grant year several studies have been undertaken. These are reported fully in References 1, 2 and 3. A summary of the technical highlights follows.

SUMMARY OF TECHNICAL HIGHLIGHTS

An extended nonlinear indicial approach to modeling nonlinear aerodynamic forces for aeroelastic analyses has been developed. The basic approach is based upon describing function ideas.

The flutter boundaries obtained by the describing function method are generally verified by time marching solutions for sufficiently small amplitude flutter motion. Hence the former, less costly method is useful for determining the significance of initial departures from linear behavior. More specific conclusions are listed below.

- Generally the accuracy of the describing function method decreases as the amplitude of the motion increases. The describing function method, however, is a powerful tool to predict the characteristics of transonic flutter since it generally requires a very small amount of computational time for the aerodynamic forces compared to time marching solutions, particularly if a parameter study is to be undertaken.

- The stable nonlinear limit cycle flutter predicted by the describing function method is also observed in the time marching solutions.

- The component in the upwash distribution due to the angular velocity, $\dot{\alpha}$, of airfoil motion cannot always be neglected even though the aerodynamic code has a low frequency limitation. Sometimes its neglect causes a fictitious flutter instability of the α-motion at high frequencies.

- The $\dot{\alpha}$ effect is properly taken into account by the total describing function decomposition into ϕ and $\dot{\alpha}$ components. $\phi = \dot{h}/U + \alpha$.

- The nonlinear behavior with the large amplitudes, $\phi > 0.5^{\circ}$, could not be obtained by the time marching solutions due to a numerical instability in the aerodynamic calculations (even when $\dot{\alpha}$ effects are included).

REFERENCES

1. Ueda, T. and Dowell, E.H., "Flutter Analysis Using Nonlinear Aerodynamic Forces", AIAA Paper 82-0728, 1982.

2. Ueda, T. and Dowell, E.H., "Describing Function Flutter Analysis for Transonic Flow: "Extension and Comparison with Time Marching Analysis", AIAA Paper 83-0958, 1983.

3. Dowell, E.H., "Unsteady Aerodynamics and Aeroelasticity", an invited paper presented at the International Symposium on Recent Advances in Aerodynamics and Aeroacoustics, August 22-26, 1983, Stanford University and NASA Ames Research Center.